1205 SEP 23 1999

PACIFIC INSTITUTE
FOR STUDIES IN DEVELOPMENT, ENVIRONMENT, AND SECURITY

Mr. Lester Snow
CALFED
1416 9th Street, Suite 1155
Sacramento, California 95814

September 22, 1999

Dear Mr. Snow,

Attached below please find my formal comments on Section 8.1.14 of the CALFED document. Thank you for the opportunity to submit these comments. Additional comments on other sections will be submitted separately.

Sincerely,

Peter Gleick

Dr. Peter H. Gleick
Director
Pacific Institute for Studies in Development, Environment, and Security

654 13TH STREET, SUITE 104
OAKLAND, CA 94612, U.S.A.
WWW.PACINST.ORG

PHONE: 510 251-1600
FAX: 510 251-2203
E-MAIL: PISTAFF@PACINST.ORG

PACIFIC INSTITUTE
FOR STUDIES IN DEVELOPMENT, ENVIRONMENT, AND SECURITY

To: Mr. Lester Snow
CALFED
1416 9th Street, Suite 1155
Sacramento, California 95814

Date: September 22, 1999
From: Dr. Peter H. Gleick, Pacific Institute for Studies in Development, Environment, and Security

Subject: Formal Comments on CALFED Section 8.1.14 Climate Change

Comments on Section 8.1.14 Climate Change

NEPA requires that federal agencies must analyze the extent to which their actions and activities may affect the emissions and sinks of greenhouse gases and the extent to which global climate changes will affect those actions and activities. The work done by CALFED substantially fails to adequately meet this NEPA requirement.

This comment will focus on the latter of the two requirements noted above: the requirement to evaluate the implications of potential climatic changes for CALFED programs. Considerable uncertainties remain in determining the precise nature and timing of global climatic changes, and especially the detailed regional implications of those changes. Nevertheless, numerous international, federal, and non-governmental reviews of the science of climate change note that these uncertainties must not prevent planning and evaluation of possible impacts from taking place. Moreover, some impacts of climate change are considerably less uncertain than others.

Impacts from climatic changes are likely to be evident well within the time frame of the projects and activities proposed by CALFED. The extremely short discussion (Section 8.1.15) by CALFED of these issues is both inadequate and inaccurate. Only two aspects of climate change are discussed: a few paragraphs on rising sea level and a three-sentence mention of possible changes in precipitation and runoff patterns.

Impacts of Sea-Level Rise for the CALFED Region

The discussion of sea level fairly accurately characterizes current best estimates of potential sea level rise, but dismisses the relevance of this issue by making an incorrect assumption:

> "While rising sea levels are potentially significant over the long term (hundreds or thousands of years), they are unlikely to significantly alter Program facilities or operations within the foreseeable future (20-50 years)" (Section 8.1.14, p. 8-13)

654 13TH STREET, SUITE 104
OAKLAND, CA 94612, U.S.A.
WWW.PACINST.ORG
PHONE: 510 251-1600
FAX: 510 251-2203
E-MAIL: PISTAFF@PACINST.ORG

This conclusion is wrong. Rising sea levels are likely to affect Program facilities within the "foreseeable future" by altering salinity gradients, the highest estimated tidal frequencies, and levee failure probabilities – all within the 20 to 50 years time horizon assumed. Research from independent sources supports this conclusion. Williams (1985, 1988), the San Francisco Bay Conservation and Development Commission (BCDC) (1988), and Gleick and Mauer (1990) addressed the issue of sea-level rise and salt-water intrusion into the San Francisco Bay-Delta region due to sea-level rise. While these assessments focused on the impacts to levees, ecosystems and coastal margins, several of them also addressed concerns about salinity intrusion near the Sacramento-San Joaquin water-supply pumps in the Delta, where the major aqueducts take their water. These assessments concluded that sea-level rise might threaten levee stability in the region, and that more salinity intrusion could affect water quality. The failure of levees could alter flow patterns in the Delta and permit more salt water to reach water intakes. Higher sea level and greater penetration of the salt front into the estuary system might require greater releases of freshwater from reservoirs to repel salinity away from water-supply intakes. In addition, Peterson, et al. (1999) noted that in northern and central California, early snowmelt also means reductions in downstream summer discharge and a risk of salinity encroachment into the Sacramento-San Joaquin Delta. This is already observed to occur during naturally warm spring periods (Cayan and Peterson 1993). These assessments typically assumed a one-meter rise, but all of the kinds of impacts noted would occur for smaller absolute increases as well. What will change is the timing and severity of the impacts. Some level of these impacts is likely to be seen within 20 to 50 years.

It is apparent from the CALFED report that no separate analyses were done using different sea levels, salinity gradients, or flow patterns. CALFED must redo model runs with new assumptions to determine the sensitivity of the results – particularly those Programmatic recommendations that involve flow patterns and salinity distributions in the Delta.

Impacts of Changes in Precipitation, Temperature, and Runoff

The second factor – changing runoff and precipitation patterns – has far more serious implications for CALFED recommendations and has been treated with even less attention and concern. In this area, significant amounts of research have been done on the implications of climatic changes for runoff in the Sacramento/San Joaquin basins. The conclusions of this work are that very serious changes in runoff timing, frequency, and magnitude are likely and that the first evidence of such changes could appear in the near future. Indeed, some evidence of changing runoff timing has already been identified, though it cannot yet be attributed to the greenhouse effect. The section below notes some of the most important conclusions from studies done on this subject for the CALFED region.

Sacramento/San Joaquin Basin Climate Impact Studies

Considerable work has been done on the impacts of climate change on the Sacramento and San Joaquin river basins. In the early 1980s, a detailed water-balance model was developed for the Sacramento Basin. This model was used to evaluate the effects of both hypothetical and GCM scenarios of climate change for annual and monthly runoff and soil moisture (Gleick, 1985, 1986a,b, 1987a,b). This analysis indicated that annual, and especially seasonal, flows would be dramatically affected by warmer temperatures, that summer flows and soil moisture could decline substantially, even with increased annual precipitation, and that winter flows and flood frequency would tend to increase. This study was one of the first to identify dramatic impacts on snow conditions as a likely impact of climatic change in basins with substantial snowfall and snowmelt. Six major temperature-driven effects were identified:

- An increase in the ratio of rain to snow, even if total precipitation amounts stay the same;
- An increase in winter runoff as a fraction of total annual runoff;
- An earlier start and faster spring snowmelt;
- A shorter snowmelt season;
- A decrease in late spring and summer runoff as a fraction of total annual runoff;
- An earlier drying of summer soil moisture.

Figure 1 offers a graphical representation of these effects. It shows two monthly hydrographs for a hypothetical basin dependent on snow for seasonal runoff. Both hydrographs have identical annual runoff totals. The first hydrograph represents the natural unimpaired average flows; the second hydrograph represents the impacts of a warming on snowfall and snowmelt dynamics. Peak runoff occurs earlier; winter runoff has higher maxima, summer runoff has lower minima, and summer drying begins earlier. Every regional modeling study has found temperature-driven hydrograph changes of this form, yet none of the CALFED modeling takes this kind of change into account.

Riebsame and Jacobs (1988) conducted an early study of how water management might be affected by global climate changes. They looked at three major issues facing California, with a focus on the Sacramento-San Joaquin region. The first was whether water infrastructure could cope with changes in variability in the timing or magnitude of runoff, given tradeoffs among water supply, flood control, hydropower, and recreation. The second was the double risk of hydrologic changes and sea-level rise for the levees and "islands" of the delta region, where much of the water withdrawals for southern California occur. The third issue was how climatic changes might affect water quality due to changes in timing and magnitude of runoff and increased intrusion of salt water from the San Francisco Bay. Riebsame and Jacobs concluded that a new form of integrated regional planning might be needed to deal with climatic impacts on Sacramento-San Joaquin basin systems. They also note "even small shifts toward earlier runoff or more extreme rainfall events would make the supply/flood-control trade-off more difficult." As demand levels rise closer and closer to the limits of supply, they concluded that the system is likely to become more sensitive to climate-induced fluctuations, requiring more effective coordination of water agencies and managers, and they raised doubts about whether this could be achieved. Again, no CALFED analysis was done for systems operations in the Bay/Delta region under climate change.

In 1990, Lettenmaier and Gan applied three climate scenarios generated from GCMs to four sub-basins of the Sacramento-San Joaquin system: the Merced, the North Fork of the American River, the McCloud, and Tomes Creek. Although these four basins differ in elevation and geophysical characteristics, some consistent results were found in the reduction of snow water equivalent in all the basins. As with the Gleick study, flood

1205(5)

frequencies rose and summer soil moisture declined. Separate analyses of the American (a tributary of the Sacramento River), Carson, and Truckee river basins also showed similar changes in seasonality (Dennis, 1991; Duell, 1992, 1994; Pupacko, 1993).

Lettenmaier and Sheer (1991), and separately, Sandberg and Manza (1991) examined the implications of climate change scenarios for the performance of the State Water Project and the federally run Central Valley Project – the two major aqueducts delivering water from the Sacramento-San Joaquin basins to central and southern California. Both studies concluded that the shifts in runoff without accompanying operational changes would challenge the systems and perhaps reduce the reliability with which the system could meet current demands. They concluded that changes in operation could, in theory, reduce the overall impacts, but noted the complex political environment that made such operational changes difficult to implement.

In the mid-1990s, the USGS used the Precipitation-Runoff Modeling System (PRMS), a physically-based, deterministic, distributed-parameter model to evaluate 25 climate change scenarios for the American and Carson river basins (Jeton et al., 1996). This work includes a far more detailed assessment of river basins than earlier water-balance models, and includes basin altitude, slope, aspect, vegetation, soil, geology, and climate. The climate scenarios studied reflected temperature changes of +/- 4.4 degrees C and +/- 25 percent of mean precipitation. Increases or decreases in precipitation, without changes in temperature, lead to relatively straightforward increases or decreases in streamflow. Changes in temperature were observed once again to lead to changes in the timing of hydrologic fluxes in the two basins. The authors concluded that annual streamflows are more sensitive to precipitation than temperature, streamflow timing is sensitive to temperature in snowmelt basins, and basin sensitivities depend on altitude more than slope, aspect, or rain shadow.

In a more recent study trying to extend our understanding of adaptation, Risbey (1998) evaluated GCM outputs in an effort to evaluate how easy or successful water-management responses might be in the Sacramento Basin. He concludes that optimism about the robustness of present planning systems in the face of potential climate change is not warranted and that climatic changes may occur that are far outside the range current water systems are prepared to handle. Yet CALFED fails to address this issue at all and ignores the large body of work that indicates it will be a problem during the lifetime of CALFED planning and projects.

Summary

Extensive research to date, ignored in the CALFED documents and assessments, supports the conclusion that climate changes will have significant impacts on the hydrology and water-management systems in the Sacramento/San Joaquin basins. Numerous independent model results also suggest consistent changes in snowfall and snowmelt timing and magnitude, which directly influence decisions about system design and operation. A difference in the timing of spring discharge alters the volume and seasonality of natural water storage. Flood probabilities change as snowmelt rates and volumes change. More research has been done on hydrologic modeling than on operational studies, water management responses, and policy options for addressing climate change, but some work is available on these issues.

Empirical evidence for this kind of change has been monitored by the California Department of Water Resources, which analyzes seasonal runoff. Figures 2 and 3 show that the fraction of total annual runoff occurring in the April-to-July period has been decreasing over the past century in the Sacramento/San Joaquin basins, with no apparent trend in total runoff. This suggests larger winter flows and decreased spring and summer flows, consistent with the snowmelt projections described above (data from CDWR, 1999). Is this evidence of climate change? No consensus on this exists, but it is indicative of the kinds of hydrologic changes that CALFED must model.

A critical aspect of the impacts of climate change on water resources is the role, responsibilities, and responses of water managers. The 1990 AAAS climate and water study noted that water managers have not been as involved in either research or policy discussions around climate change as they should be and made an unsuccessful effort to bring water managers into the process (Waggoner, 1990). Others have noted this as well (Schilling and Stakhiv, 1998). In 1997, the American Water Works Association (AWWA) published a series of recommendations for water managers that included reexamining engineering design assumptions, operating rules, and contingency planning under a wider range of climatic conditions than normally considered, as well as working with climate scientists to facilitate the exchange of information on climate change and water resources (AWWA 1997). A critical point of these recommendations was that water managers can no longer assume that their systems will be resilient and robust under conditions of climate change, but must more aggressively re-evaluate that assumption. Yet CALFED ignores these recommendations by the leading U.S. water management organization and fails to include these assessments in this analysis.

Significant uncertainties remain about the likely impacts of climatic change on precipitation intensity and patterns. These uncertainties will not be resolved until higher resolution climate models are available that can incorporate the complex geophysical characteristics of the western U.S., including orographic effects and storm tracks originating in both the Pacific Ocean and the Gulf of Mexico. Additional work is needed to improve regional assessments at all scales and to develop appropriate policy responses in the face of uncertainty.

Despite these gaps, some consistent and important conclusions can be drawn from these assessments, with important lessons – and responsibilities – for water managers and planners at CALFED. The seasonality and timing of runoff in these basins will shift as temperatures begin to rise. In particular, winter runoff is likely to increase as the ratio of rain to snow increases and as snowpacks melt faster. This increases the risk of winter flooding, which is already a serious risk in these basins. At the same time, summer water availability is likely to decrease, as spring runoff begins and ends earlier. This increases the risk that seasonal water shortages or deficits will become more likely. These possible consequences of climate change have not been taken into account in any of the traditional regional water-resources planning or policy assessments.

Cited References

American Water Works Association, 1997. Climate change and water resources. Journal of the American Water Works Association, Vol. 89, No. 11, pp. 107-110.

Bay Conservation and Development Commission (BCDC), 1988. Sea level rise: Predictions and implicatons for San Francisco Bay. San Francisco Bay Conservation and Development Commission, California. 100 pp.

California Department of Water Resources (CDWR), 1999. Hydrographic data for unimpaired flows in the Sacramento-San Joaquin rivers. Available at http://cdec.water.ca.gov, text file "wsihist".

Dennis, A.S., 1991. Initial climate change scenario for the western United States. Global Climate Change Response Program, United States Department of the Interior, Bureau of Reclamation, Denver, Colorado.

Duell, L.F.D. Jr., 1992. Use of regression models to estimate effects of climate change on seasonal streamflow in the American and Carson River Basins, California-Nevada. In Managing Water Resources during Global Change. Proceedings of the 28th American Water Resources Association Annual Conference, Bethesda, Maryland.

Duell, L.F.D. Jr., 1994. The sensitivity of northern Sierra Nevada streamflow to climate change. Water Resources Bulletin, Vol. 30, No. 5, pp. 841-859.

Gleick, P.H., 1985. Regional hydrologic impacts of global climatic changes. Proceedings of an International Research and Development Conference, Arid Lands: Today and Tomorrow. (E.E. Whitehead, C.F. Hutchinson, B.N. Timmermann, and R.G. Varady, editors). October 20-25, 1985. University of Arizona, Office of Arid Lands Studies, Tucson, Arizona. pp. 43-60.

Gleick, P.H., 1986a. Methods for evaluating the regional hydrologic impacts of global climatic changes. Journal of Hydrology. Vol. 88, pp. 97-116.

Gleick, P.H., 1986b. Regional water resources and global climatic change: The state-of-the-art. In J.G. Titus (editor), Effects of Changes in Stratospheric Ozone and Global Climate: Volume 3: Climate Change. United States Environmental Protection Agency/United Nations Environment Programme. (October)

Gleick, P.H., 1987a. The development and testing of a water-balance model for climate impact assessment: Modeling the Sacramento Basin. Water Resources Research. Vol. 23, No. 6, pp. 1049-1061.

Gleick, P.H., 1987b. Regional hydrologic consequences of increases in atmospheric carbon dioxide and other trace gases. Climatic Change. Vol. 10, No. 2, pp. 137-161.

Gleick, P.H., 1990b. Vulnerabilities of water systems. In P. Waggoner (ed.) Climate Change and U.S. Water Resources. (J. Wiley and Sons, Inc., New York.) pp. 223-240.

Gleick, P.H. and E.P. Maurer. 1990. Assessing the costs of adapting to sea-level rise: A case study of San Francisco Bay. Pacific Institute for Studies in Development,

1205(8)

Environment, and Security, Berkeley, California and the Stockholm Environment Institute, Stockholm, Sweden. 57 pp. with 2 maps.

Gleick, P.H. and B. Chalecki. 1999. The impacts of climatic changes for water resources of the Colorado and Sacramento-San Joaquin river basins. Journal of the American Water Resources Association. In press.

Jeton, A.E., M.D. Dettinger, and J.L. Smith, 1996. Potential effects of climate change on streamflow, Eastern and Western slopes of the Sierra Nevada, California and Nevada. U.S. Geological Survey, Water Resources Investigations Report 95-4260. Sacramento, California.

Lettenmaier, D.P. and T.Y. Gan, 1990. Hydrologic sensitivities of the Sacramento-San Joaquin River Basin, California, to global warming. Water Resources Research, Vol. 26, No. 1, pp. 69-86.

Lettenmaier, D.P. and D.P. Sheer, 1991. Climate sensitivity of California water resources. Journal of Water Resources Planning and Management, Vol 117, No. 1, pp. 108-125.

Peterson, D.H., R.H. Smith, M.D. Dettinger, D.R. Cayan, and L. Riddle, 1999. An organized signal in snowmelt runoff over the west. In American Water Resources Association Specialty Conference on Potential Consequences of Climate Variability and Change to Water Resources of the United States, May 10-12. Atlanta, Georgia. Pp 129-137.

Pupacko, A., 1993. Variations in northern Sierra Nevada streamflow – Implications of climate change. Water Resources Bulletin, Vol. 29, pp. 283-290.

Riebsame, W.E. and J.W. Jacobs, 1988. Climate change and water resources in the Sacramento-San Joaquin region of California. Natural Hazards Research and Applications Information Center Working Paper #64, University of Colorado, Boulder.

Risbey, J.S., 1998. Sensitivities of water supply planning decisions to streamflow and climate scenario uncertainties. Water Policy, Vol. 1, No. 3, pp. 321-340.

Sandberg, J. and P. Manza, 1991. Evaluation of Central Valley Project water supply and delivery system. Global Change Response Program, U.S. Department of Interior, Bureau of Reclamation, Sacramento, California.

Schilling, K.E. and E.Z. Stakhiv, 1998. Global change and water resources management. Water Resources Update, Vol. 112, pp. 1-5.

Waggoner, P. (ed.), 1990. Climate Change and U.S. Water Resources. (J. Wiley and Sons, Inc., New York.)

Williams, P.B., 1985. An overview of the impact of accelerated sea level rise on San Francisco Bay. Philip B. Williams and Associates, San Francisco, California. 19 pp.

Williams, P.B., 1988. The impacts of climate change on salinity of San Francisco Bay. Philip B. Williams and Associates, San Francisco, California. 29 pp.